The Beam-Plasma Interactions Experiment

Completed Technology Project (2017 - 2020)

Project Introduction

We propose a 'mother-daughter' rocket experiment to test the physics of beam-plasma-wave interactions. In this experiment the primary (mother) rocket payload is an electron accelerator that will produce a beam of energetic electrons that generates electromagnetic plasma wave modes as it propagates through the ambient ionospheric plasma. The secondary (daughter) payload separates from the mother, travels to a higher altitude, and measures the waves as they propagate upward from the mother into the upper ionosphere and magnetosphere. The daughter payload consists of 3D electric probes, magnetic search coils, a waveform-capture radio receiver, a Langmuir probe and an electron detector. Plasma physics theory predicts two possible outcomes based on different numerical assumptions. The two theories make dramatically different predictions for the dependence of radiated wave power as a function of the electron beam energy and pitch angle. The traditional ('two-mode') theory predicts that wave power is a sharply-peaked function of injected beam energy. The peak wave power (at beam energies ~10 keV) is expected to be 2-3 orders of magnitude larger than at lower (~1 keV) or higher (~50 keV) beam energies. More recent theoretical treatments predict a 'one-mode' solution to the beam-plasma interaction equations. In the one-mode theory there is no peak in wave power. Rather wave power decreases monotonically as beam energies increase from ~1 to ~50 keV and the predicted absolute beam-to-wave energy conversion is predicted to be up to 100X more efficient than predicted by the two-mode theory. Our experiment will measure all the beam, wave, and particle parameters that are used in the theoretical calculations: the ambient magnetic field vector, plasma density and temperature, wave spectral density, wave normal vector, Poynting flux, beam energy, and pitch angle. We will vary the beam energy over the range ~1 to >50 keV and pitch angle over ~0-90°. The measurements will fully test the two competing theories of how electron beams in space produce propagating electromagnetic waves in the ionosphere and magnetosphere. A secondary science objective is to measure the effect of the beam-generated waves on the ambient ionospheric plasma. Once the waves are generated by the electron beam they transfer wave energy to the background plasma by pitch angle scattering ambient electrons. The effect of pitch angle scattering is to partially fill the atmospheric 'loss cone' as measured by the electron detector on the daughter. The experiment strongly supports NASA's Heliophysics science goals - particularly "investigations of the physics of magnetospheres, including fundamental interactions of plasmas and particles with fields and waves, and coupling to the solar wind and ionospheres." Recent NASA missions (including THEMIS, Van Allen probes, and MMS) have identified wave-particle interactions as key processes mediating the transfer of energy within different parts of the solar wind, magnetosphere, and ionosphere. The Beam-Plasma Interactions Experiment will test our fundamental understanding of the underlying physical interactions using a unique active-experimental approach.

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Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Los Alamos National Security, LLC

Responsible Program:

Heliophysics Technology and Instrument Development for Science

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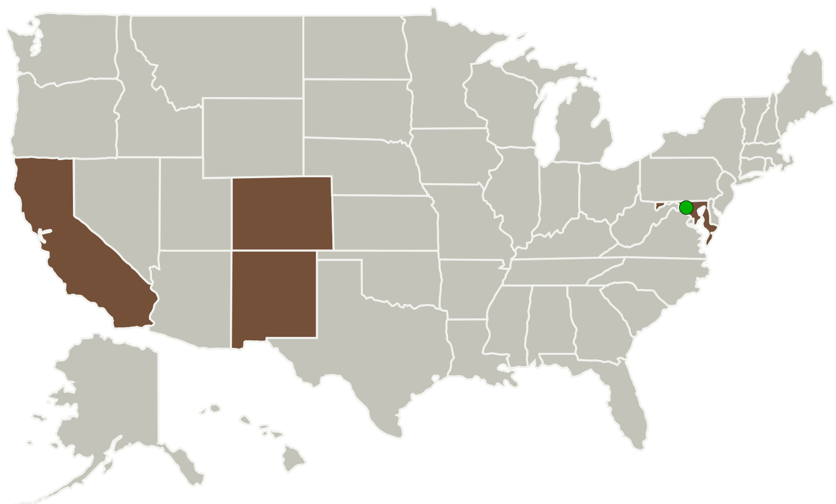
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Los Alamos National Security, LLC	Lead Organization	Industry	Los Alamos, New Mexico
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland
Los Alamos National Laboratory(LANL)	Supporting Organization	R&D Center	Los Alamos, New Mexico
Space Science Institute	Supporting Organization	Industry	Boulder, Colorado
SRI International	Supporting Organization	Industry	Menlo Park, California
University of Calgary	Supporting Organization	Academia	Calgary, Outside the United States, Canada

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

Geoffrey D Reeves

Co-Investigators:

Bruce Carlsten
Emma L Spanswick
William M Farrell
Joseph Borovsky
Ashley R Herrera
Gian Luca Delzanno
Dinh C Nguyen
Eric Donovan
Robert F Pfaff
Philip A Fernandes
Douglas E Rowland
Michael A Holloway
Ennio R Sanchez
John W Lewellen
Maria Samara

Technology Areas

Primary:

- TX01 Propulsion Systems
  └ TX01.4 Advanced Propulsion
    └ TX01.4.4 Other Advanced Propulsion Approaches

Target Destination

The Sun

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Primary U.S. Work Locations	
California	Colorado
Maryland	New Mexico